SUNY The State University of New York

An Introduction to Green Infrastructure

And Application to Campus Environments

Doug Johnston
Professor and Chair
Department of Landscape Architecture

ESF State University of New York
College of Environmental Science and Forestry

Outline of Talk

Part I

- Some water (and other) problems
- Definition(s) of Green Infrastructure
- Types and Typologies of GI

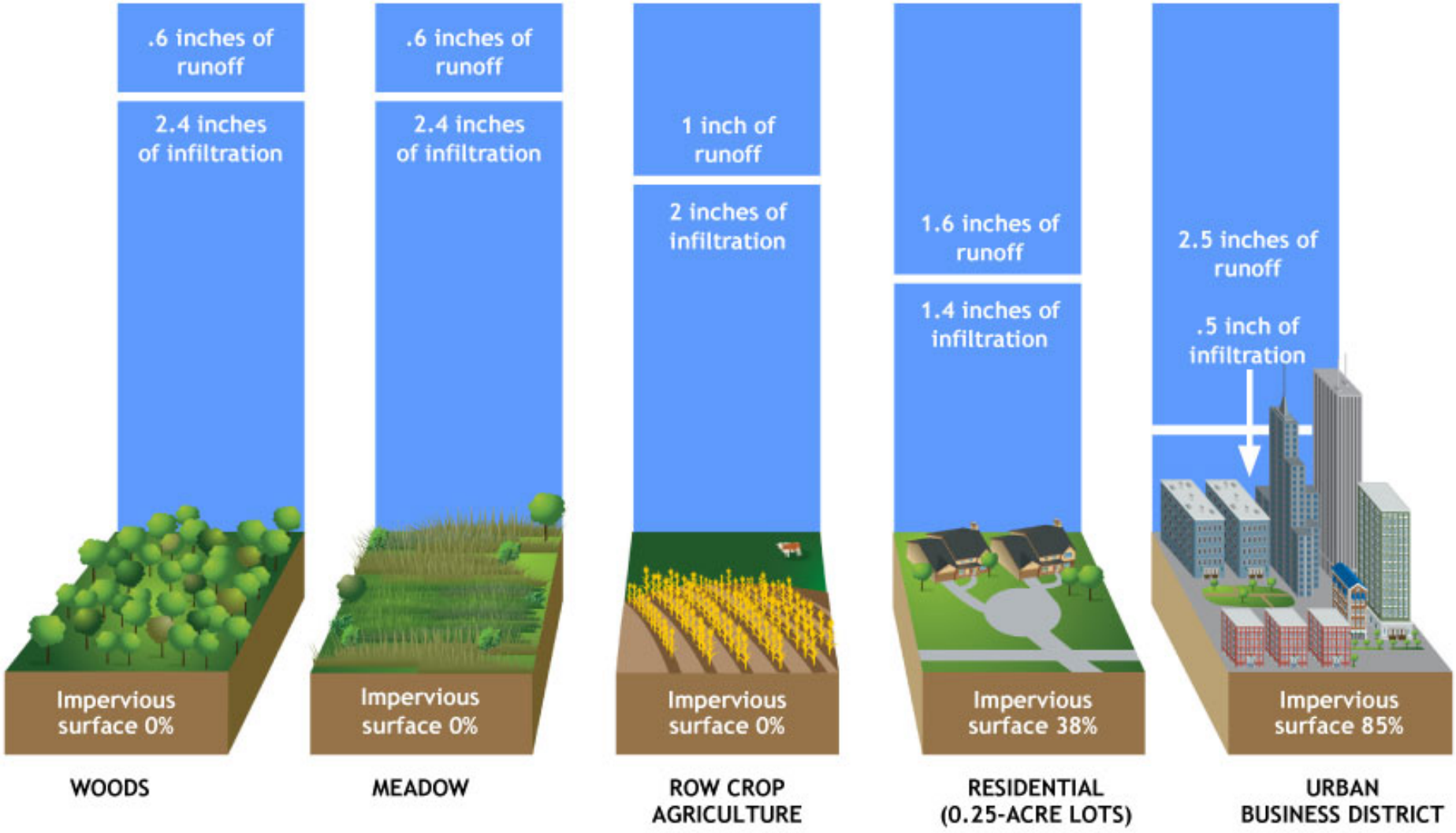
Part II

- Teaching and Research Aspects of GI
- GI at Universities

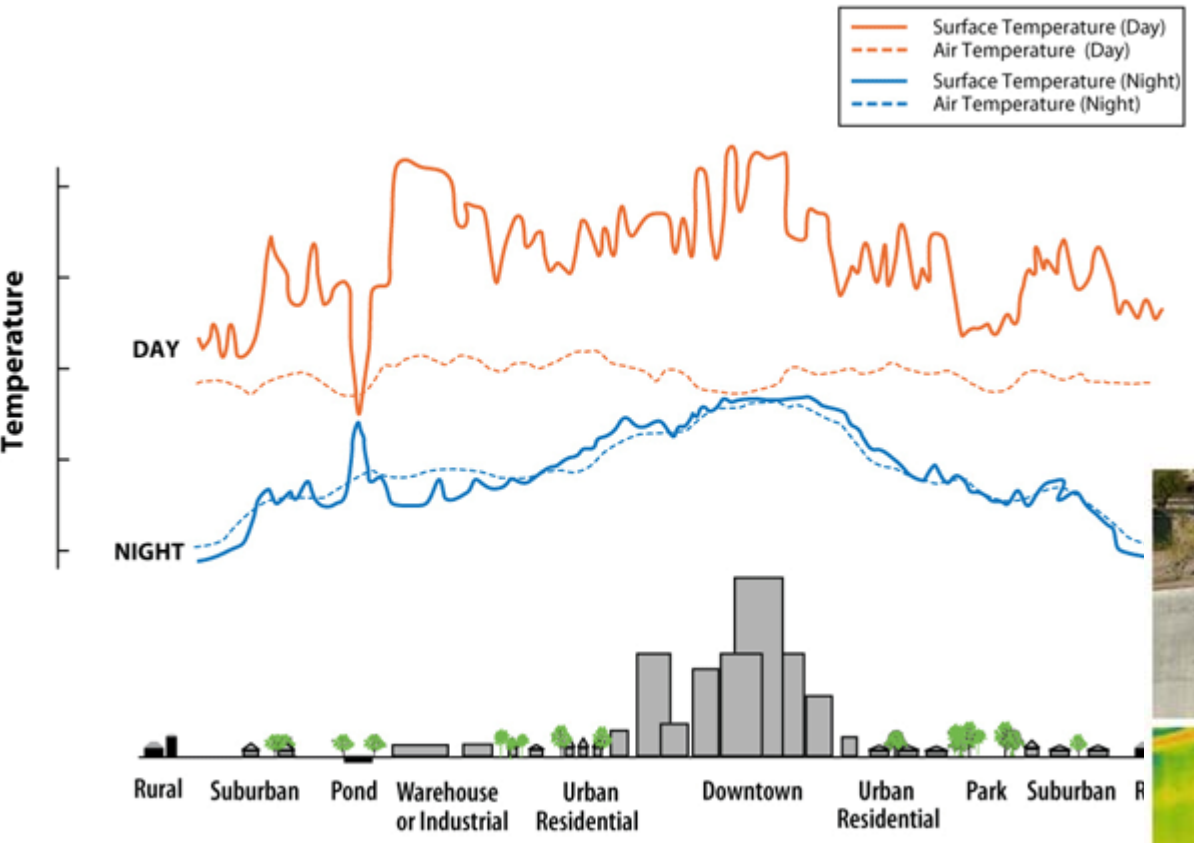
Too Much Water

Iowa State University,
August, 2011

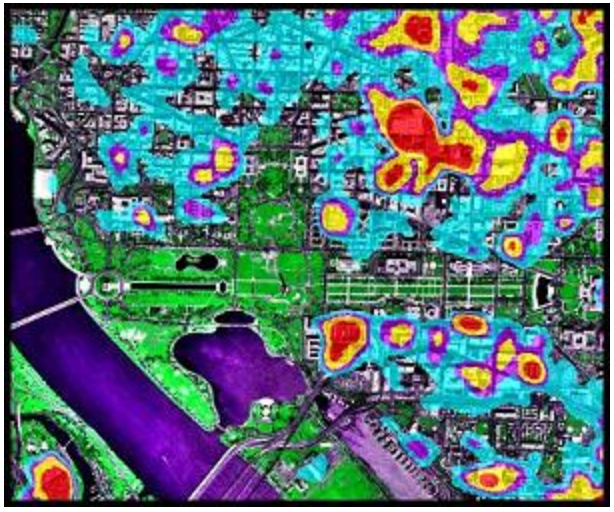
Where does the water go?

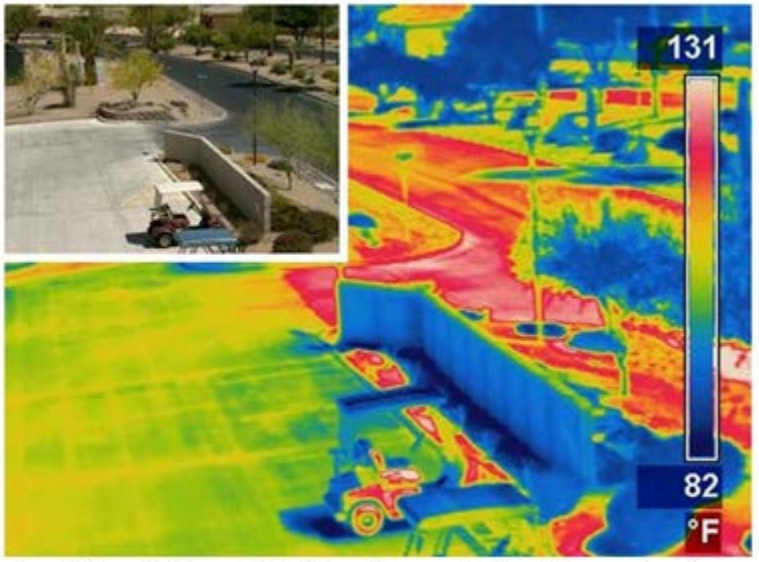


Urban Heat Island



http://www.epa.gov/heatisland/images/UHI_profile-rev-big.gif



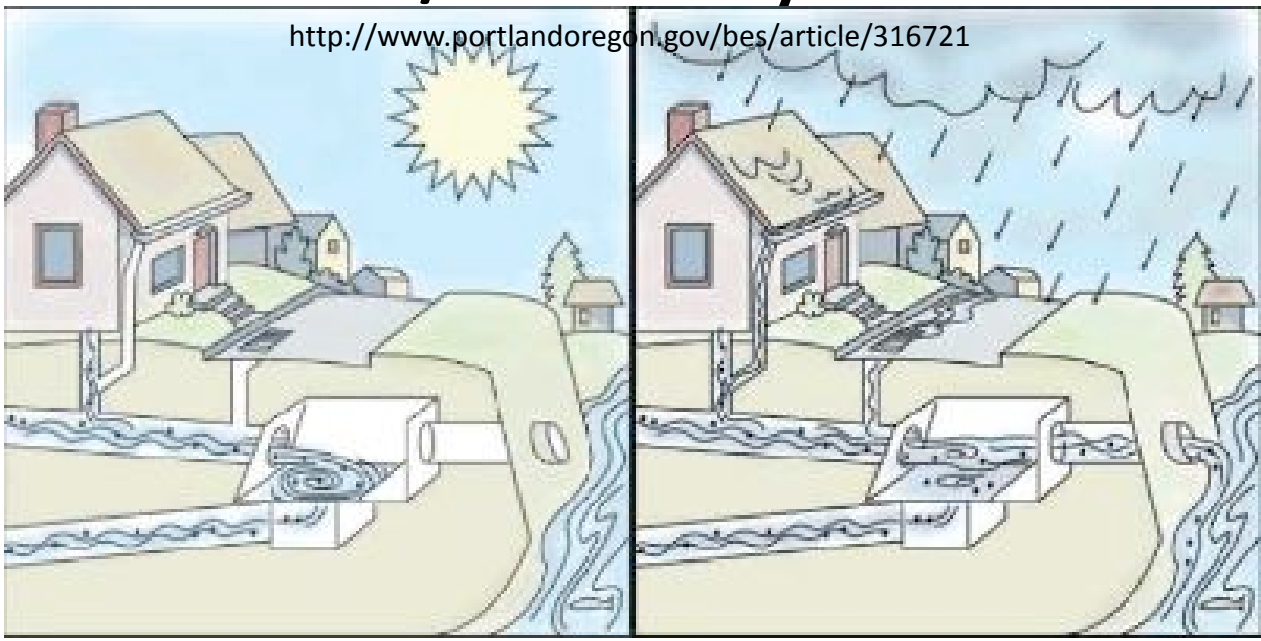


Kamil Kaloush, Arizona State University, presentation "Pavements and the Urban Heat Island Effect" EPA 's Cool Pavement Webcast Jan 28 2010

Combined Storm Water/Sanitary Sewers

- Good News: Urban storm water treated during small rainfall events

- Bad News: Raw sewage and urban storm water dumped to waterways w/o treatment during large rainfalls



http://www.portlandoregon.gov/bes/article/316721

WATER
ENVIRONMENT
PROTECTION
ONONDAGA COUNTY
DEPARTMENT OF WATER ENVIRONMENT PROTECTION
COMBINED SEWER OUTFALL
SPDES NO: NY 0027081
This pipe may discharge sewage & storm water during and immediately following wet weather events.
It should not be active during dry weather. If you observe this pipe discharging during dry weather, please report it immediately to (315) 435-3157
For information or questions call:
(315) 435-2260 or (315) 435-3157

http://www.ongov.net/wep/we1802.html

Problems of Definition

- **Green Infrastructure** is a concept originating in the United States in the mid-1990s that highlights the importance of the natural environment in decisions about land-use planning. However, the term does not have a widely recognised **definition**.

  Green infrastructure - Wikipedia, the free encyclopediaen.wikipedia.org/wiki/Green_infrastructure

The concept actually goes back 110 years before the 1990s!

Boston's Back Bay Fens (1879)

7505

Two definitions of green infrastructure

- An inter-connected network of green open spaces that provide a range of ecosystem services — from clean air and water to wildlife habitat and carbon sinks.
- A more limited one promoted by the E.P.A.: small-scale green systems designed to be urban stormwater management infrastructure.

In either definition, green infrastructure is about bringing together “natural and built environments” and using the “landscape as infrastructure”.

http://dirt.asla.org/2013/04/25/green-infrastructure-a-landscape-approach/

Some More Common Types

Type	Treatment Effect
Water Harvesting	Water Quantity
Permeable Paving	Water Quantity (Water Quality) (Heat Island)
Appropriate Plant Selection	Water Quantity Water Quality
Green Roofs	Building Energy Heat Island Water Quantity
Bioretention/Phytoremediation	Water Quantity Water Quality (Heat Island)
Urban Forestry	Water Quantity Water Quality Heat Island
Landscape Systems	WQ, WQ, HI

GI Strategies for Water Management

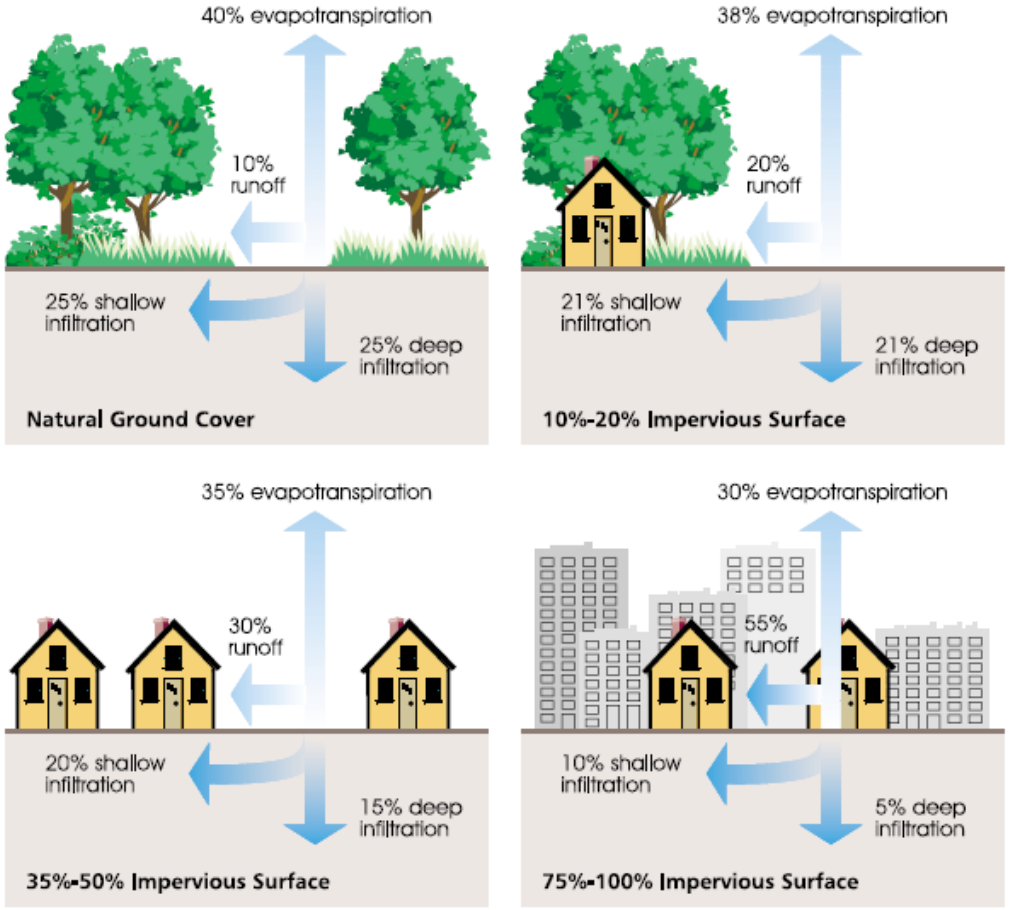


Figure 1.2. Runoff Variability with Increased Impervious Surfaces (FISRWG, 1998)

Restore (or mimic) "natural" hydrology

- Capture Rainfall
- Increase Permeability
- Increase Evapotranspiration
- Slow it down

Water Harvesting

Restore (or mimic) "natural" hydrology

- Capture Rainfall
- Increase Permeability
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http://www.chicagogreentech.org/

Permeable Paving

Restore (or mimic) “natural” hydrology

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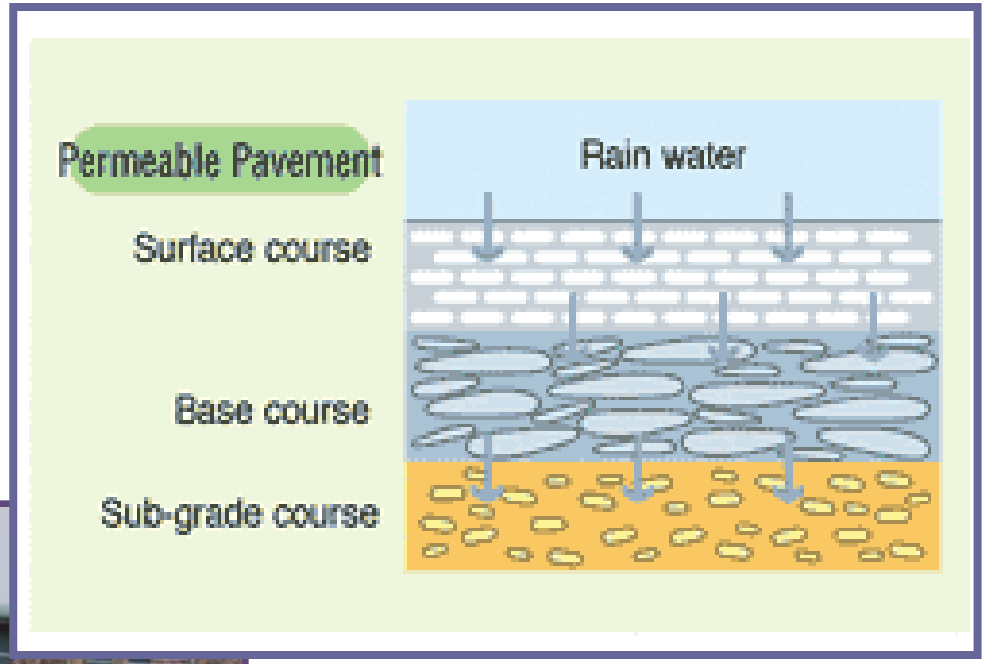

Appropriate Plant Selection

Restore (or mimic) “natural” hydrology

- Capture Rainfall
- Increase Permeability
- Increase Evapotranspiration
- Slow it down

http://crocosmia.co.uk/gardens.html

Green Roofs

Restore (or mimic) “natural” hydrology

- Capture Rainfall
- Increase Permeability
- Increase Evapotranspiration
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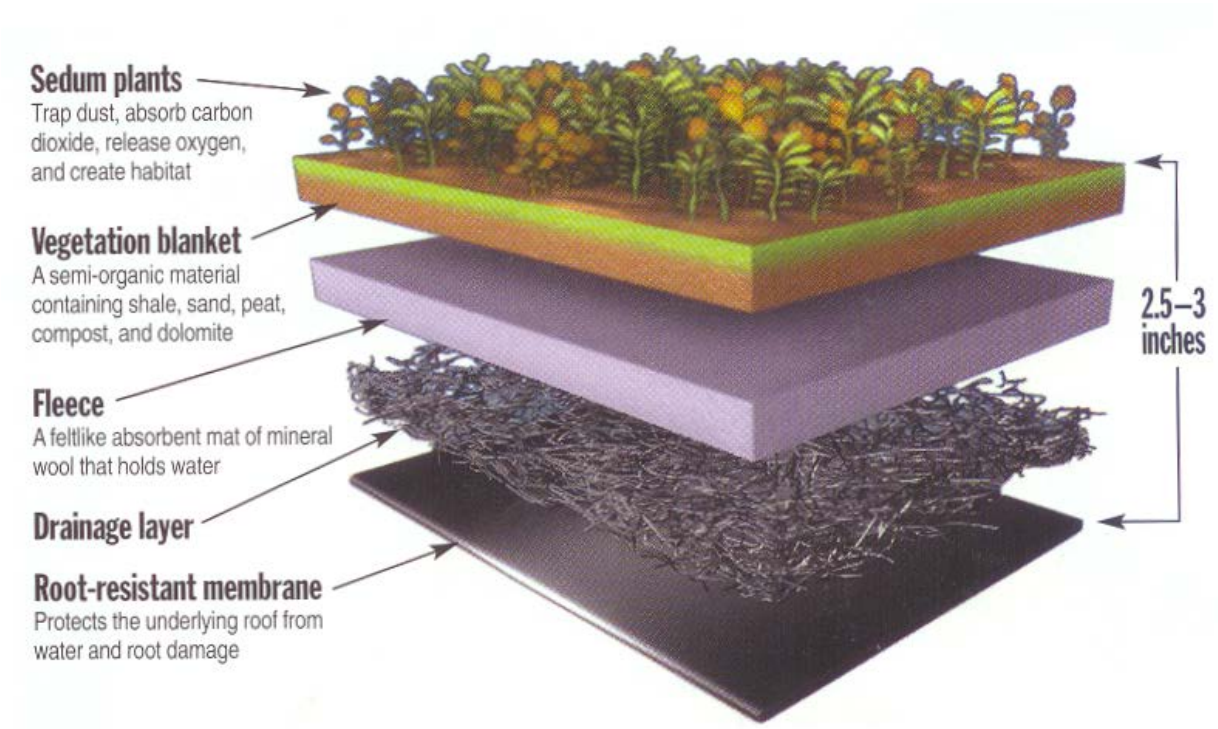
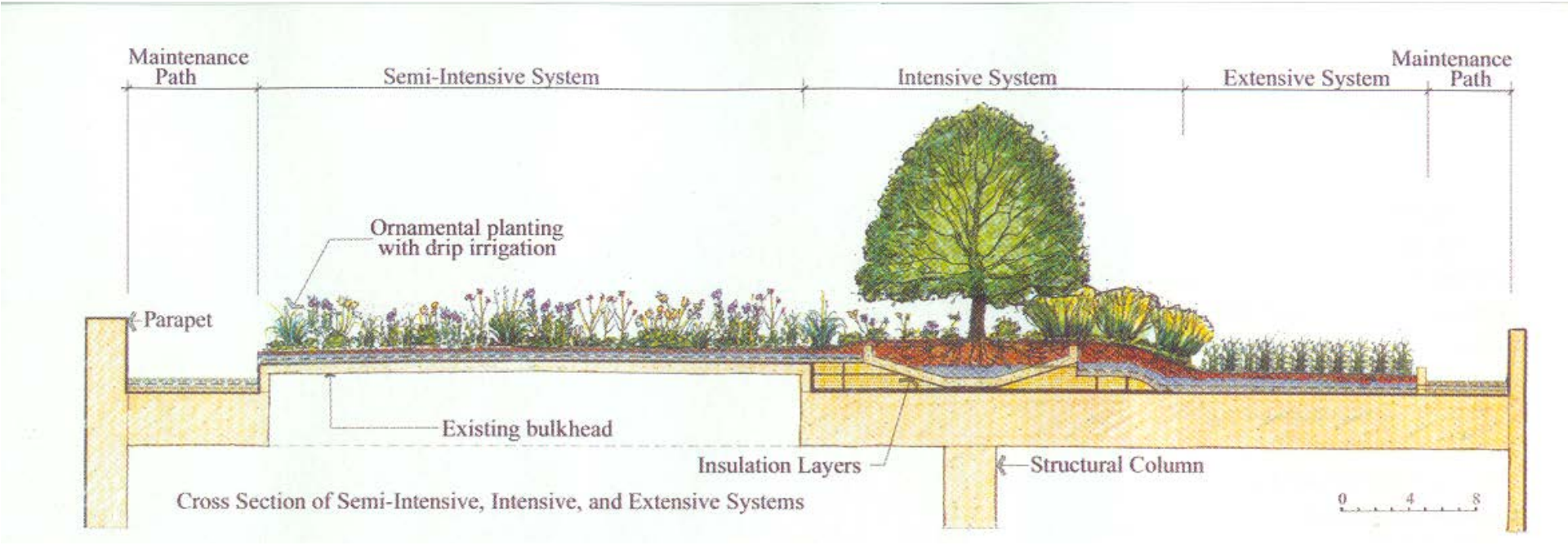

Sedum plants
Trap dust, absorb carbon dioxide, release oxygen, and create habitat
Vegetation blanket
A semi-organic material containing shale, sand, peat, compost, and dolomite
Fleece
A feltlike absorbent mat of mineral wool that holds water
Drainage layer
Root-resistant membrane
Protects the underlying roof from water and root damage
2.5–3 inches



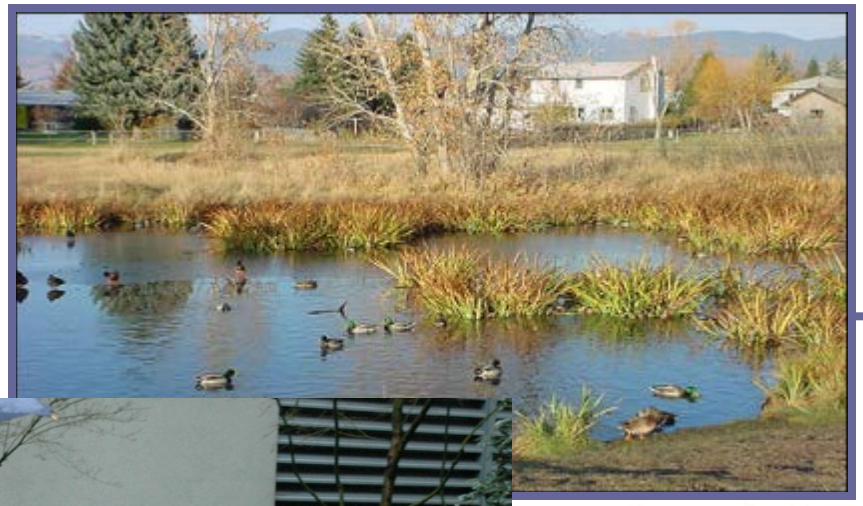
Cité Scolaire Internationale, Lyon, France

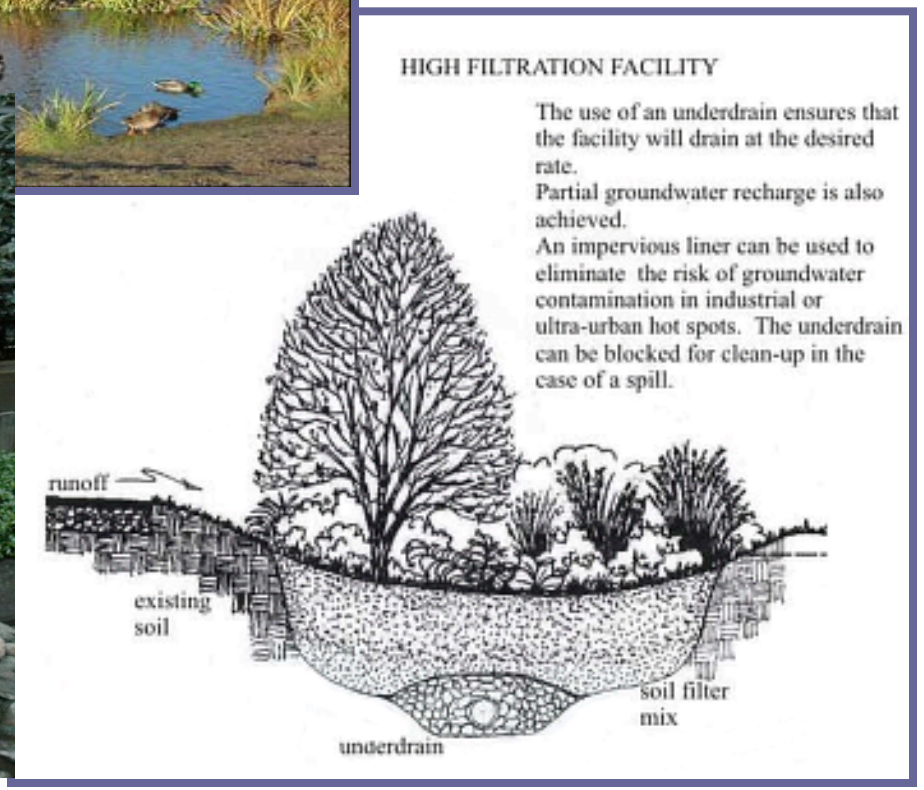
- ***Françoise-Hélène Jourda et de Gilles Perraudin* , 1992**

Green Roof Benefits

- Direct and indirect cost savings opportunities for the building owner, such as:
  - Increased insulation value, resulting in savings on energy heating and cooling costs.
  - Potential for greenhouse gas emissions trading credits.
  - The possible easing of impervious coverage restrictions for developers who incorporate green roofs into their site plans.
  - Provision of amenity space and aesthetic appeal, increasing the value of the property and the marketability of the city as a whole.
  - Visual and environmental benefits that increase property value.

Bioretention / Bioinfiltration: Filter strips, drainage swales, and naturalized detention ponds (rain gardens)




HIGH FILTRATION FACILITY
The use of an underdrain ensures that the facility will drain at the desired rate.
Partial groundwater recharge is also achieved.
An impervious liner can be used to eliminate the risk of groundwater contamination in industrial or ultra-urban hot spots. The underdrain can be blocked for clean-up in the case of a spill.
runoff
existing soil
soil filter mix
underdrain

Phytoremediation

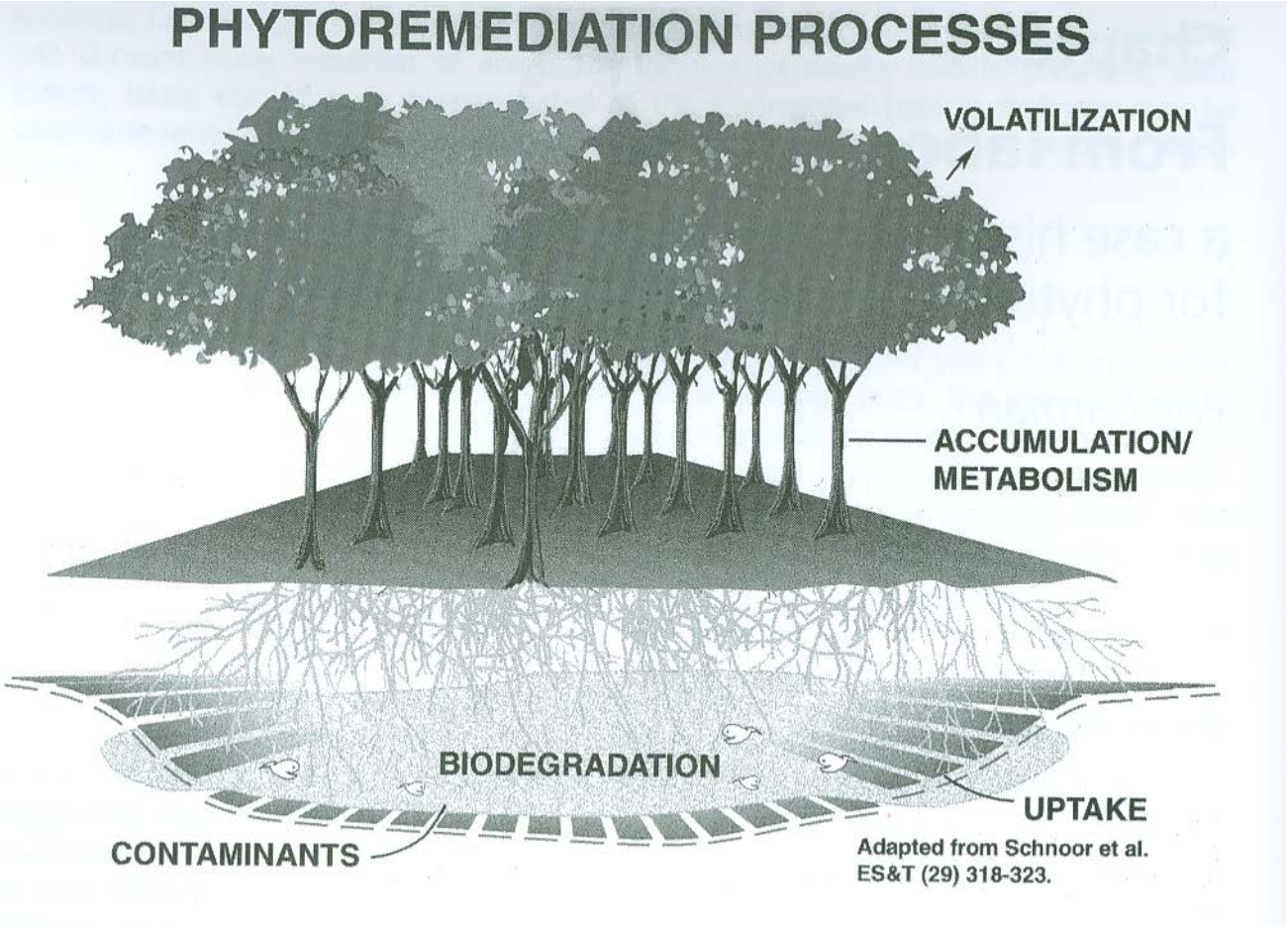


Figure 4.1 Phytoremediation processes include direct uptake, accumulation, biodegradation or volatilization of contaminants, and enhancement of biodegradation processes in the rhizosphere

Bioretention / Phytoremediation: An Urban Example

4 FORO URBANO DE PAISAJE
LANDSCAPE URBAN FORUM
PAISAIA REN HIRI FOROA
VITORIA-GASTEIZ 2012

Urban Forestry

PAISAJES EN RED
NETWORKING LANDSCAPES

Hacia una Infraestructura Verde Urbana integrada en la escala Bio-regional
Towards an Urban Green Infrastructure integrated in the Bioregional scale

2012 **PROGRAMA**

http://www.vitoria-gasteiz.org/ceac/

22	MARZO MARCH	CONFERENCIA TÉCNICA Técnicas de Diseño Medioambiental en Edificación y Renovación Urbana Luis Álvarez Ude Mesa redonda con Albert Cuchí · Juan Rubio del Val · Gerardo Wadel	TECHNICAL CONFERENCE Environmental Design Techniques in Building and Urban Renovation Luis Alvarez Ude Round table with Albert Cuchi · Juan Rubio del Val · Gerardo Wadel
11-21	JUNIO JUNE	TALLER INTERNACIONAL Paisaje, Arquitectura y Urbanismo: Infraestructura Verde en la ciudad Con la dirección de Emanuel Carter · Anne Whiston Spirn · José Fariña Tojo	INTERNATIONAL WORKSHOP Landscape, Architecture and Urbanism: Green Infrastructure in the city Scientific management by Emanuel Carter · Anne Whiston Spirn · Jose Fariña
22-23	JUNIO JUNE	CONGRESO INTERNACIONAL Infraestructura Verde en la ciudad: El papel de los espacios naturales y rurales periurbanos Con la organización y coordinación de FEDENATUR	INTERNATIONAL CONGRESS Green Infrastructure in the city: The role of periurban natural and rural spaces Organisation and coordination by FEDENATUR
18	OCTUBRE OCTOBER	CASOS PRÁCTICOS Infraestructura Verde Urbana y Regional en las Redes UNESCO Red de Reservas de la Biosfera de Canadá, Dyfi (Gales), Sao Paulo (Brasil), Hamburgo (Alemania), Urdaibai y Anillo de las Tierras Altas de Alava Central (País Vasco) Con la participación prevista de Janez Potocnik · Jaime Lerner · Federico Mayor Zaragoza	CASE STUDIES Urban and Regional Green Infrastructure in UNESCO Networks Biosphere Reserves Network of Canada, Dyfi (Wales), Sao Paulo (Brasil), Hamburg (Germany), Urdaibai and Upland Ring of Central Alava (Basque Country) With the planned participation of Janez Potocnik · Jaime Lerner · Federico Mayor Zaragoza

Urban Forestry

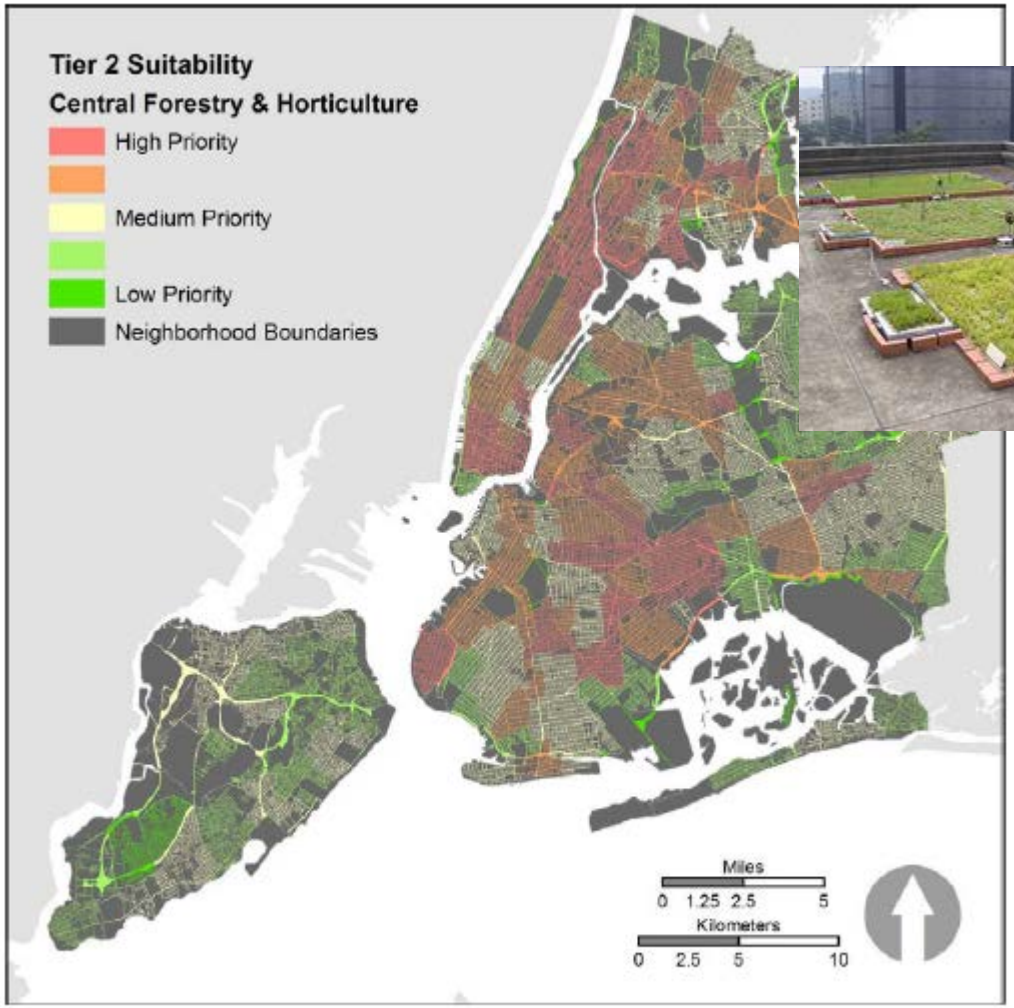
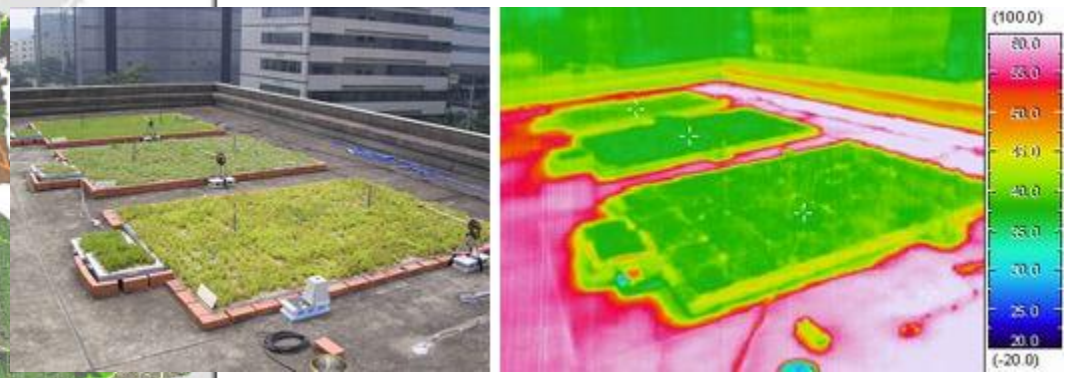


Figure 9. Tier 2 map created for Central Forestry and Horticulture. The Public Right of Way was assessed and ranked for Possible UTC. That ranking was concatenated behind the neighborhood ranking.

Title: Prioritizing preferable locations for increasing urban tree canopy in New York City
Author: Locke, Dexter; Grove, J. Morgan; Lu, Jacqueline W.T.; Troy, Austin; O'Neil-Dunne, Jarlath P.M.; Beck, Brian.
Year: 2010
Publication: Cities and the Environment 3(1):18 p.

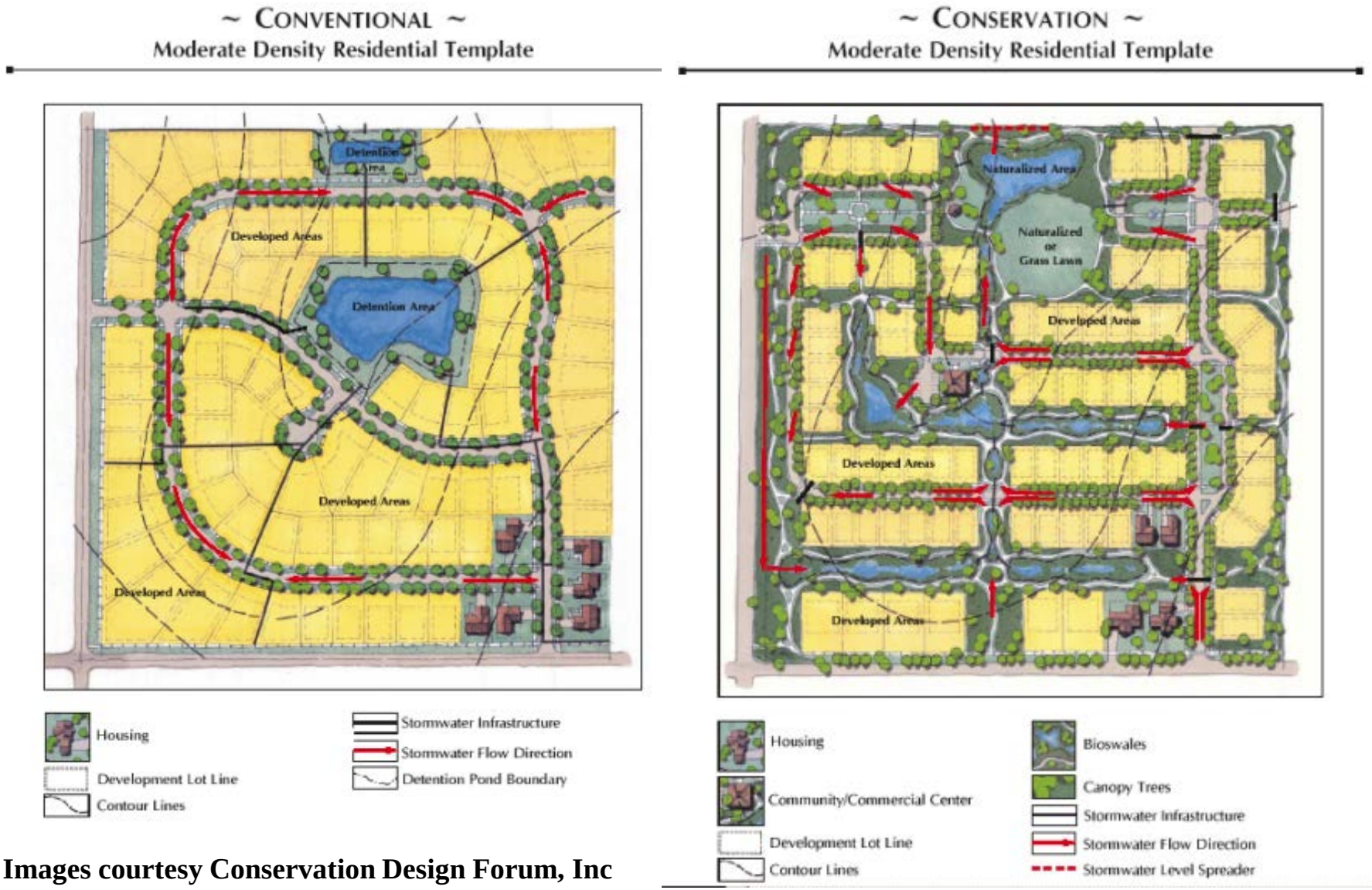


http://www.japanfs.org/en/news/archives/news_id027856.html

i-Tree

NRS scientists have worked with numerous collaborators to develop the i-Tree suite of urban forestry software that is designed to help assess and manage urban forests.

Landscape Systems…



Images courtesy Conservation Design Forum, Inc

GI Benefits Typology

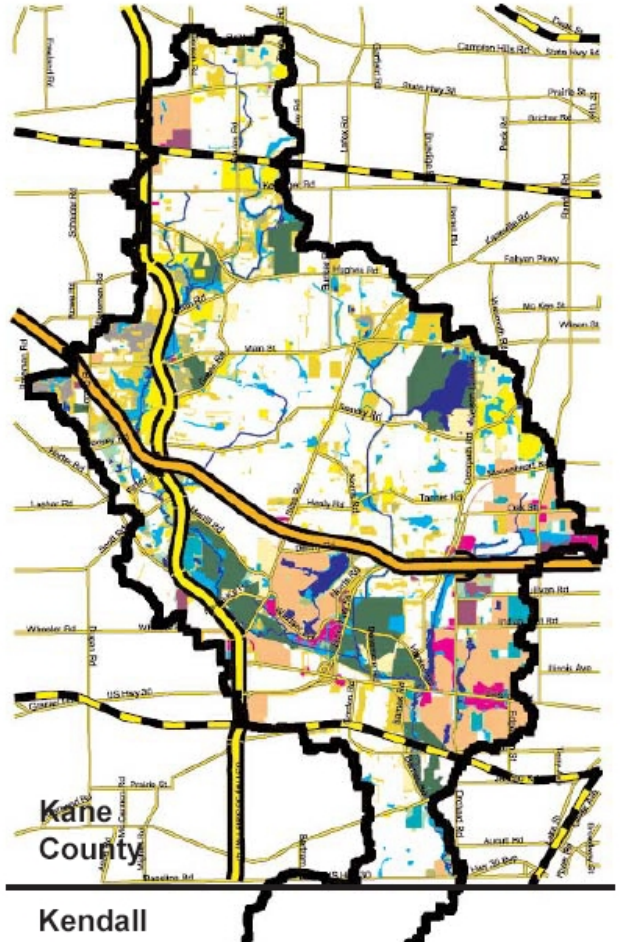
- Reduced Flood Damages (frequency/scale)
- Smaller Drainage Infrastructure
- Reduced Pollution Treatment (low flow, storm flow)
- Reduced Erosion/Sediment Transport
- Improved Water Quality
- Improved In-stream Biota
- Improved Aesthetics
- Increased Infiltration/Groundwater Recharge

Valuation Issues

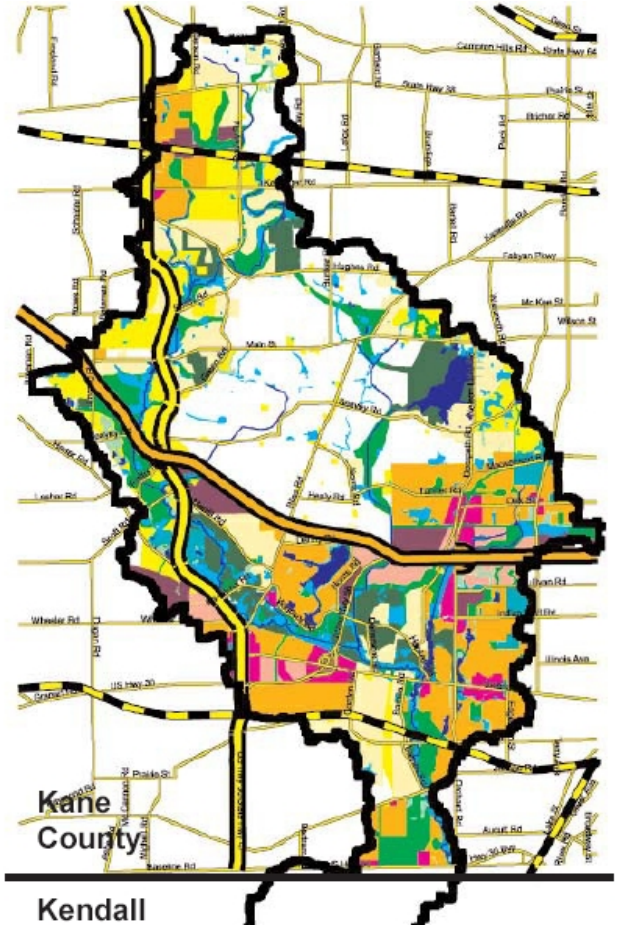
1. Costs vs. Benefits
   - Do the benefits outweigh the costs?
   - Cost does not equal value.
   - Who incurs the costs, who receives the benefits?
2. Marginal vs. Total Value
   - Damages not eliminated, only reduced
   - Ecological services unpriced at margin (in small increments)
3. Transferability
   - Location (if it worked there, will it work here?)
   - Time (if it worked then, will it work now – and into the future?)
   - Scale (if it worked in a small area, will it be as effective if applied to a large area?)

Landscape System Case Study

(Blackberry Creek, Chicago Region)



Existing Land Use



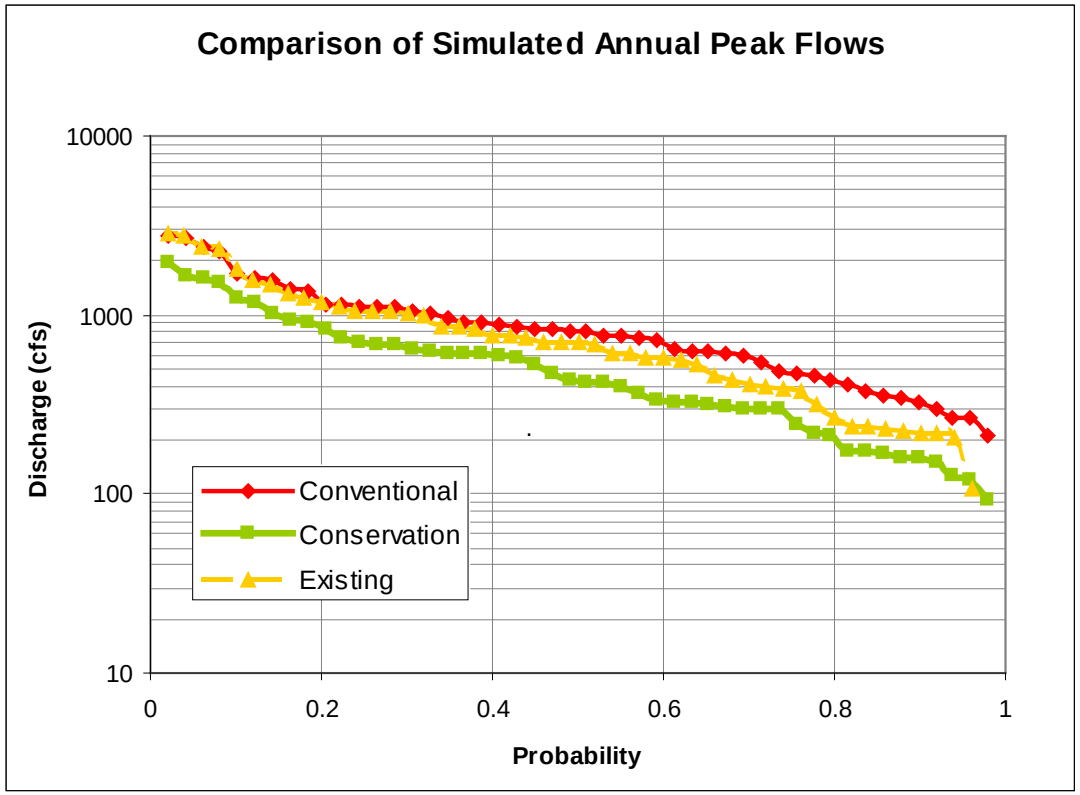
Planned Land Use

Methodology

- Hydrologic simulation.
  - Simulate discharge (flow rates) for reaches based on future conditions (Conventional vs. Green Infrastructure) -- HSPF.
  - Calculate the flood heights along the reaches (HEC-RAS).
  - Estimate the extent of flooding (high-resolution DEM).
- Flood reduction benefit.
  - Estimate the area of different land uses contained within the flooded extent.
  - Calculate the economic benefits attributable to the differences in flooded extent between scenarios.
- Conventional Infrastructure benefits.
  - Calculate size differences for scenarios and comparative costs.

Hydrology Results

- Average of a 40% reduction in peak flows in the conservation design scenario
- Water surface elevation (flood stage) differences between the two scenarios range from 0 ft in headwater areas to 1.5 feet at the mouth of the watershed
- Velocities in the streams are also lower in the conservation scenario

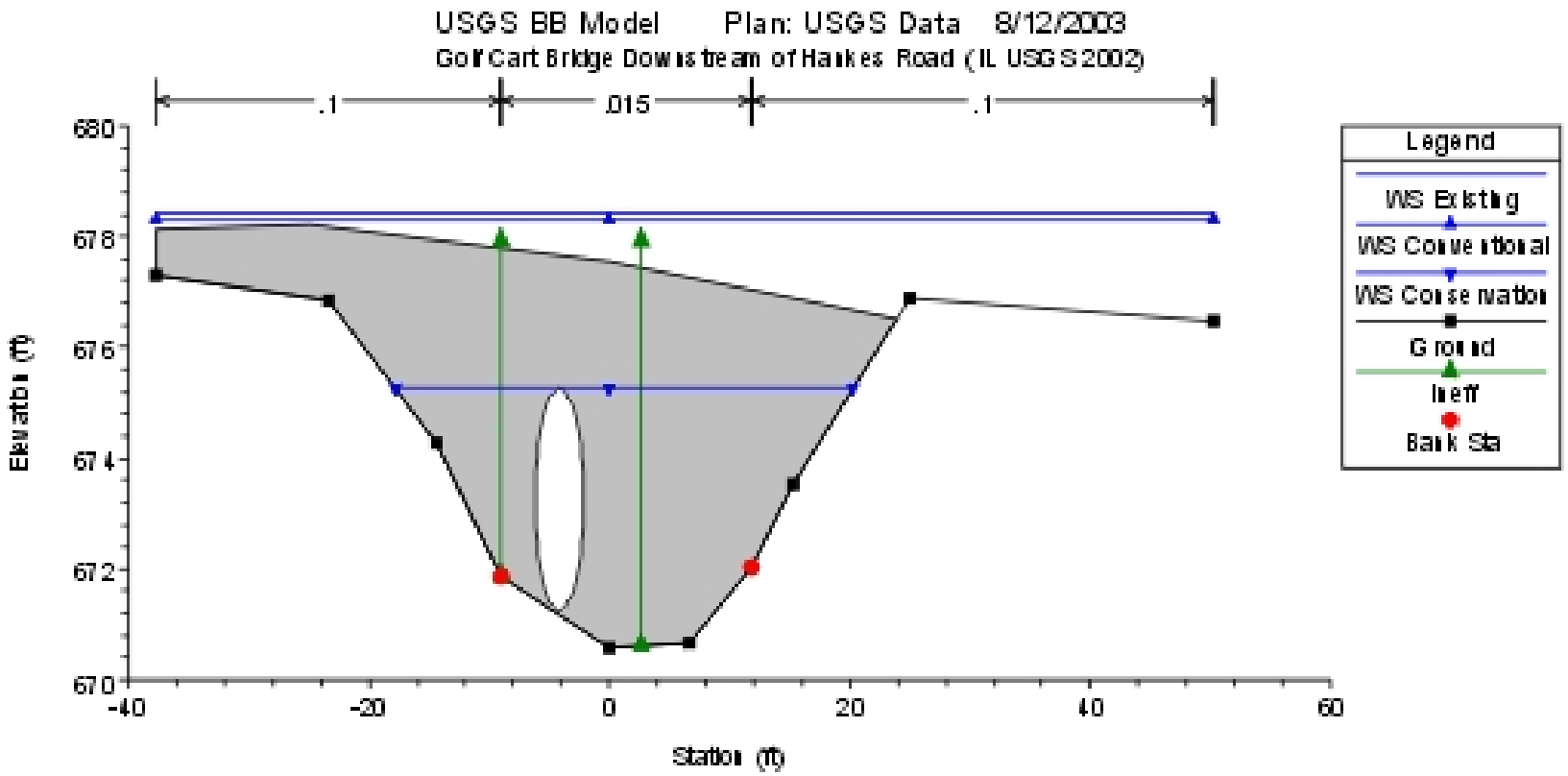


Flood Reduction Benefits
(0.01 annual probability event)

Flood Depth	Est. Structural Damage		Est. Content Damage		Acres Flooded	Total Damages		
	%Damage	/Hectare	%Damage	/Hectare	Hectares	Structural	Content	Total
0	13.40%	$ 129,663	8.10%	$ 78,378	21.9	$ 2,836,771	$ 1,714,764	$ 4,551,535
1	23.30%	$ 225,459	13.30%	$ 128,695	15.5	$ 3,505,383	$ 2,000,927	$ 5,506,310
2	32.10%	$ 310,610	17.90%	$ 173,206	18.1	$ 5,620,535	$ 3,134,193	$ 8,754,728
3	40.10%	$ 388,021	22.00%	$ 212,879	14.9	$ 5,780,287	$ 3,171,230	$ 8,951,517
4	47.10%	$ 455,755	25.70%	$ 248,682	13.8	$ 6,305,444	$ 3,440,550	$ 9,745,994
5	53.20%	$ 514,781	28.80%	$ 278,679	8.8	$ 4,535,410	$ 2,455,260	$ 6,990,670
6	58.60%	$ 567,033	31.50%	$ 304,805	2.6	$ 1,468,554	$ 789,411	$ 2,257,965
7	63.20%	$ 611,545	33.80%	$ 327,060	1.7	$ 1,057,846	$ 565,747	$ 1,623,592
8	67.20%	$ 650,250	35.70%	$ 345,445	0.3	$ 172,484	$ 91,632	$ 264,117
9	70.50%	$ 682,182	37.20%	$ 359,960	0.1	$ 74,138	$ 39,119	$ 113,257
				Total	**97.8**	**$ 31,356,852**	**$ 17,402,832**	**$ 48,759,684**
Property Value per Hectare		Property Value per Acre				**Expected Value**		**$ 487,597**
$ 967,634		$ 391,601				**Present Value (@5%)**		**$ 9,751,937**
						PV/Hectare		**$ 99,757**

Conventional Development – 1 Story Structures

Infrastructure Estimation



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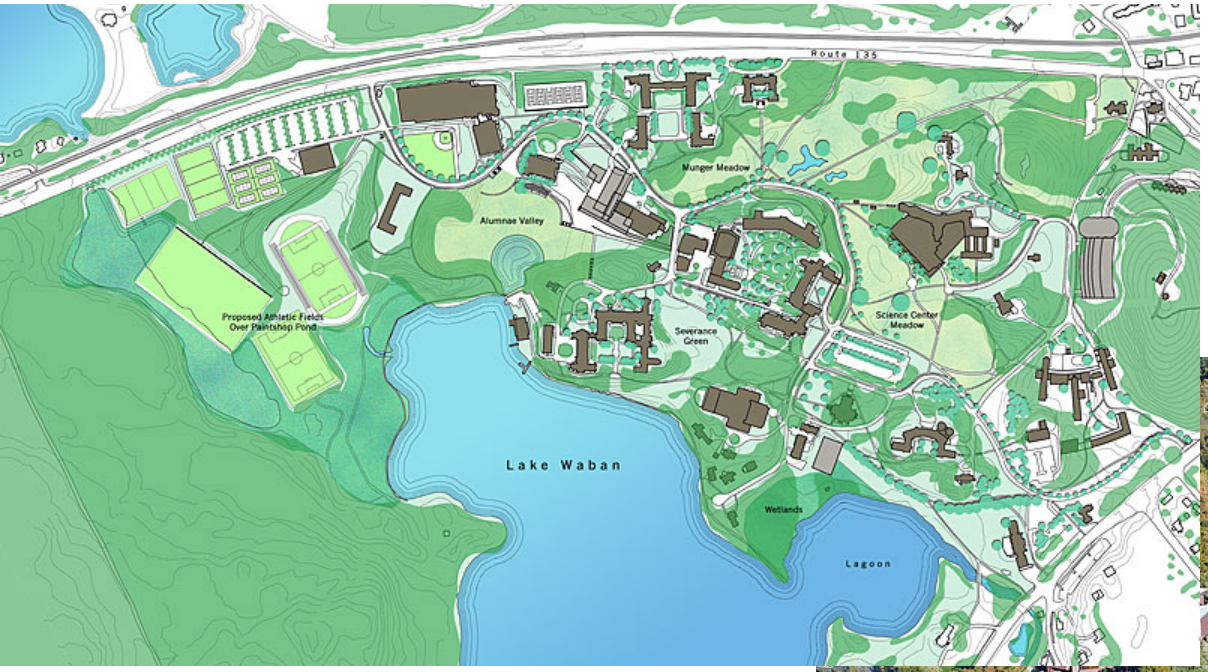
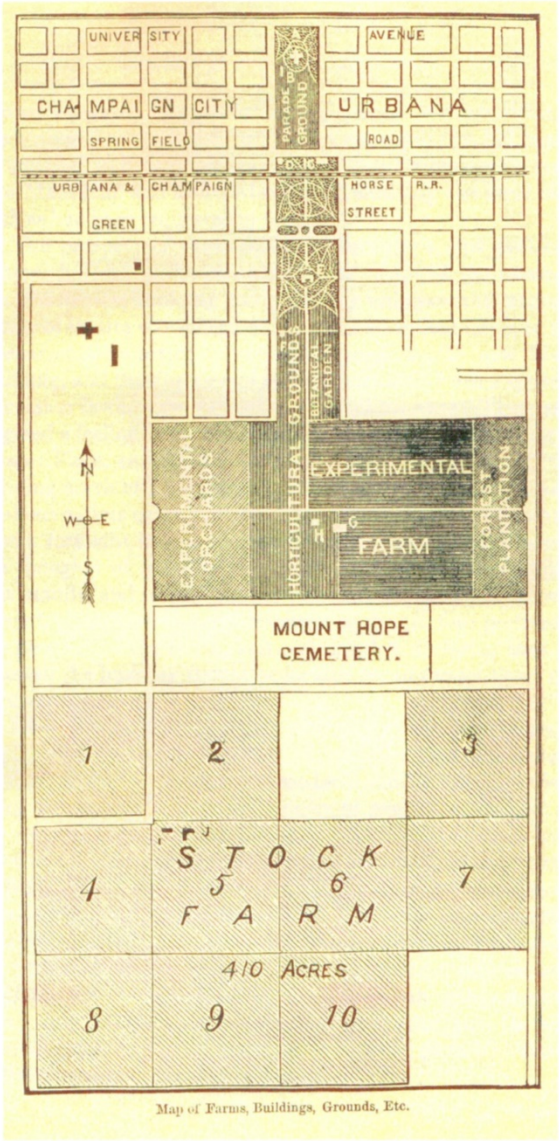
WELLESLEY COLLEGE MASTER PLAN

Wellesley, MA (1997–1999)

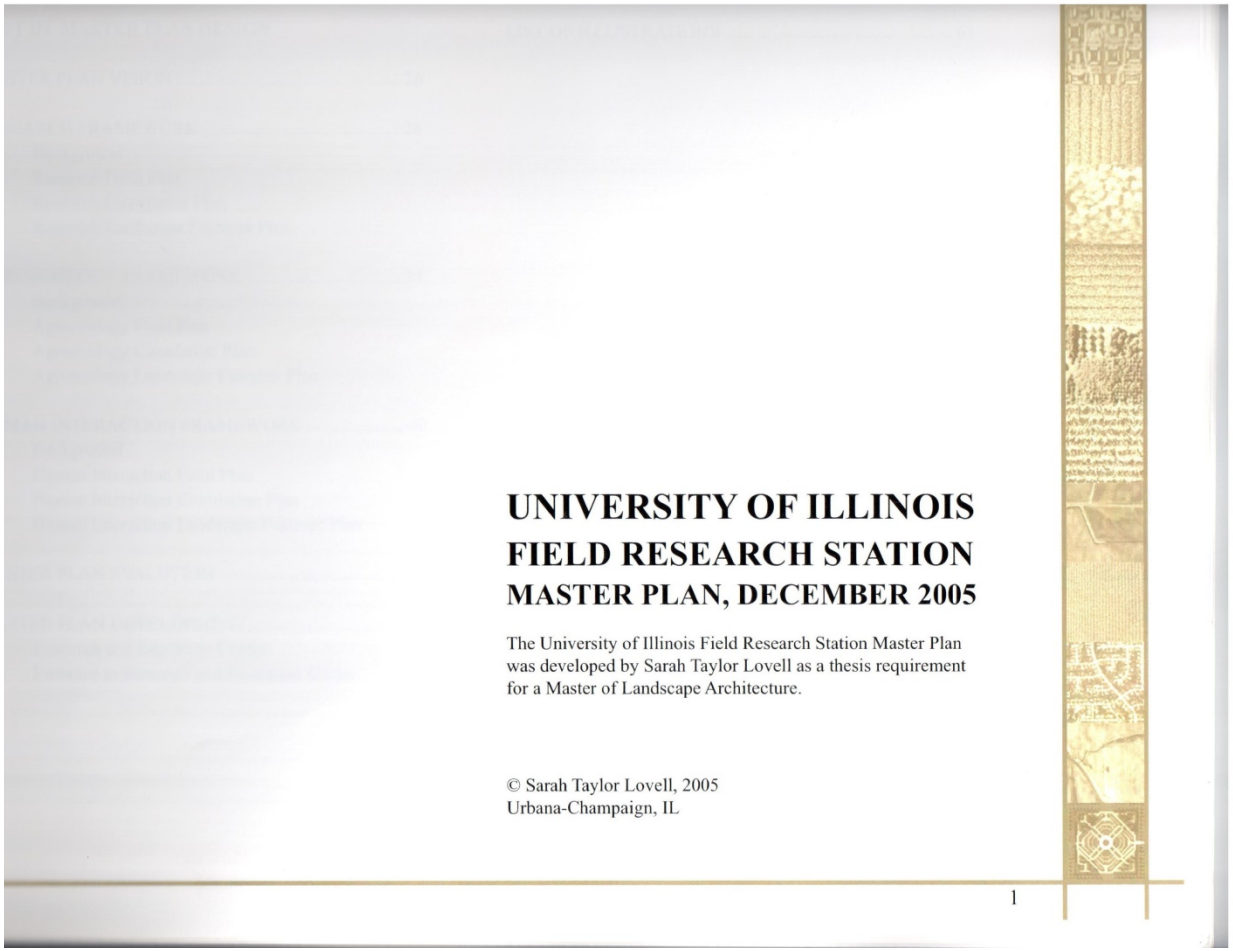
Michael VanValkenburg, Landscape Architect



University of Illinois South Campus Master Plan

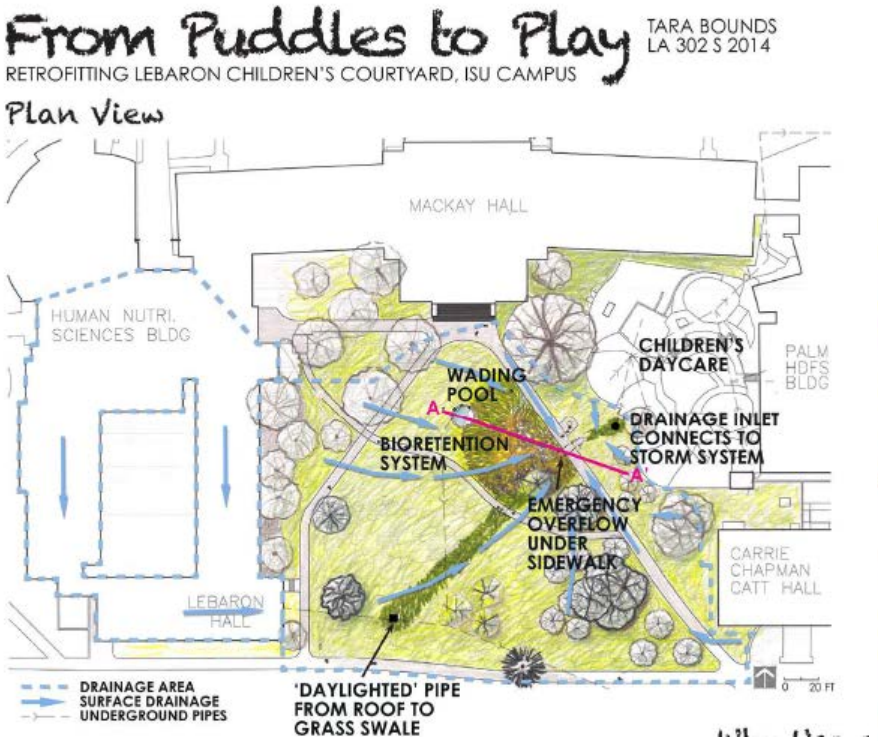


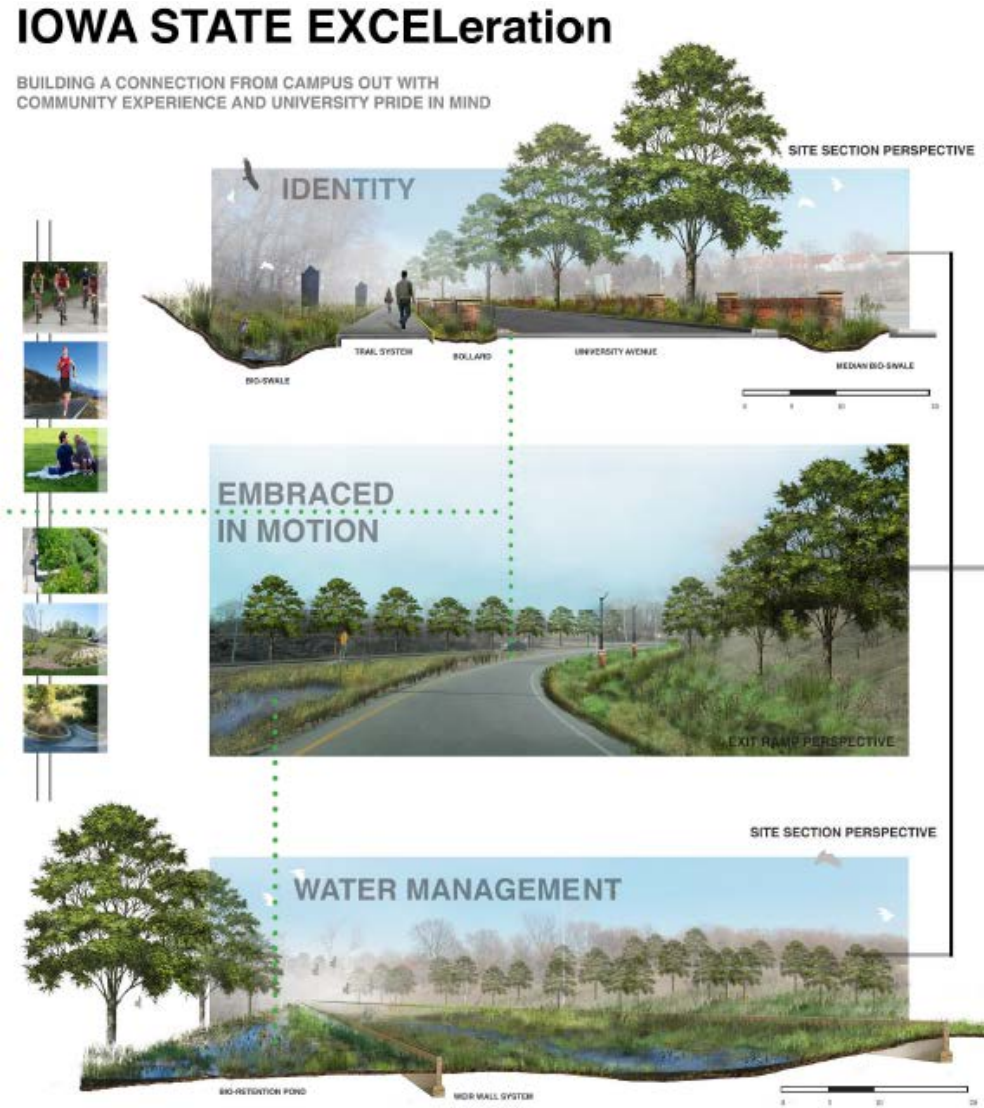
Map of campus printed in 1871.


UNIVERSITY OF ILLINOIS
FIELD RESEARCH STATION
MASTER PLAN, DECEMBER 2005
The University of Illinois Field Research Station Master Plan was developed by Sarah Taylor Lovell as a thesis requirement for a Master of Landscape Architecture.
© Sarah Taylor Lovell, 2005
Urbana-Champaign, IL
1

IOWA STATE UNIVERSITY

Student Explorations in Collaboration with Facilities Management



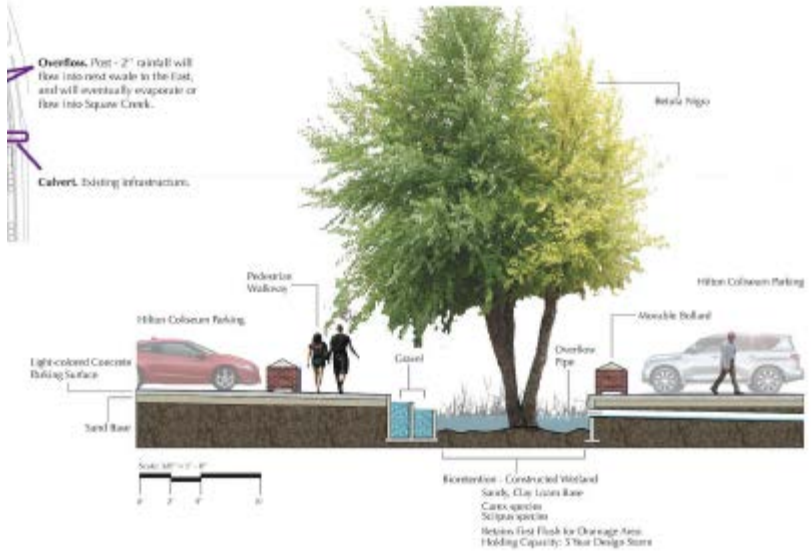

IOWA STATE EXCELeration
BUILDING A CONNECTION FROM CAMPUS OUT WITH COMMUNITY EXPERIENCE AND UNIVERSITY PRIDE IN MIND
SITE SECTION PERSPECTIVE
IDENTITY
EMBRACED IN MOTION
SITE SECTION PERSPECTIVE
WATER MANAGEMENT

IOWA STATE UNIVERSITY

CAMPUS GATEWAY

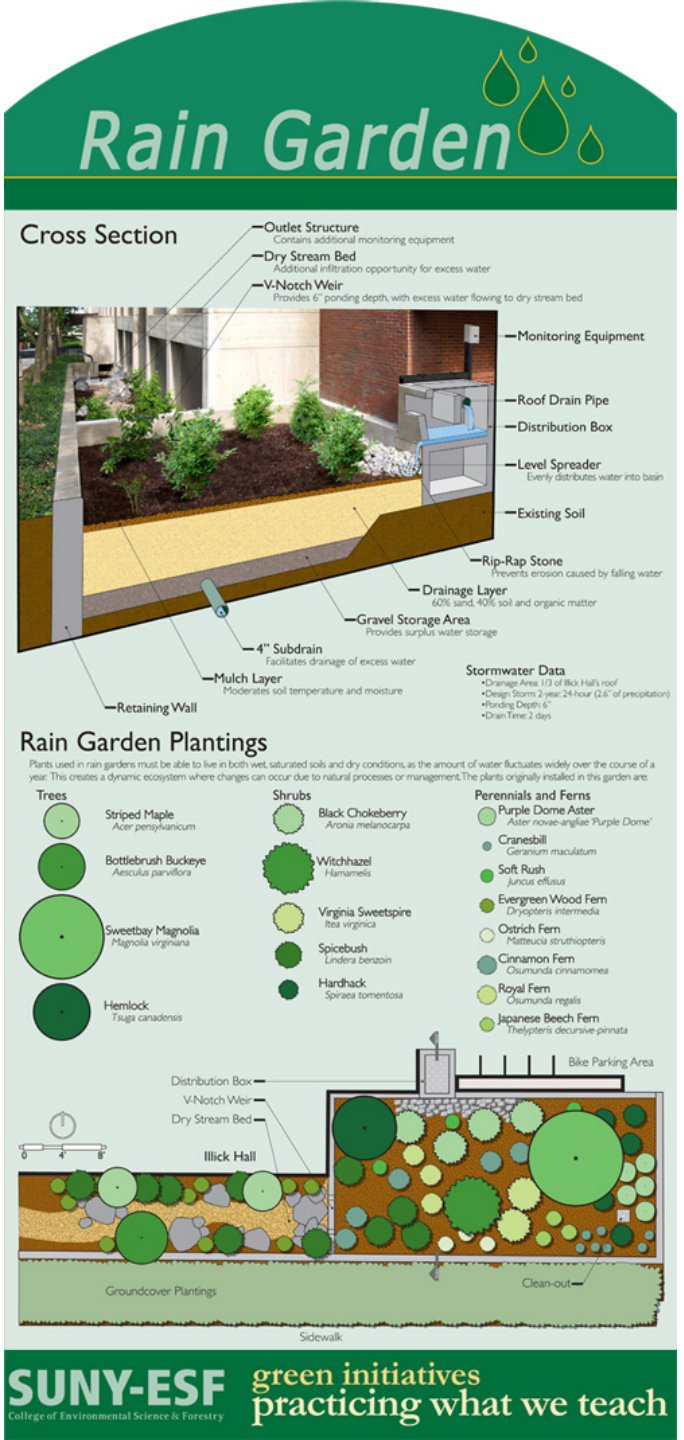
REIMAN GARDENS

DESIGN BY: DEVON GOTTSCHALK


Overflow. Post - 2" rainfall will flow into next swale in the East, and will eventually evaporate or flow into Squaw Creek.
Calvert. Existing infrastructure.
Betula Nigra
Pedestrian Walkways
Hilton Coliseum Parking
Hilton Coliseum Parking
Movable Bollard
Overflow Pipe
Gravel
Light-colored Concrete Parking Surface
Sand Base
Bioretention - Constructed Wetland
Sands, Clay Loams Base
Carex species
Scirpus species
Helenium Host Flush for Drainage Area
Holding Capacity: 5 Year Design Storm

On the ESF Campus

http://www.esf.edu/sustainability/action/raingarden.htm



ESF Gateway Center Green Roof

- Architect: Architerra, Inc
- Landscape Architect: Andropogon Associates, Ltd.
- ESF Faculty Research:
  - Don Leopold, Environment and Forest Biology
  - Tim Toland, Landscape Architecture
  - Doug Daley, Environmental Resources Engineering

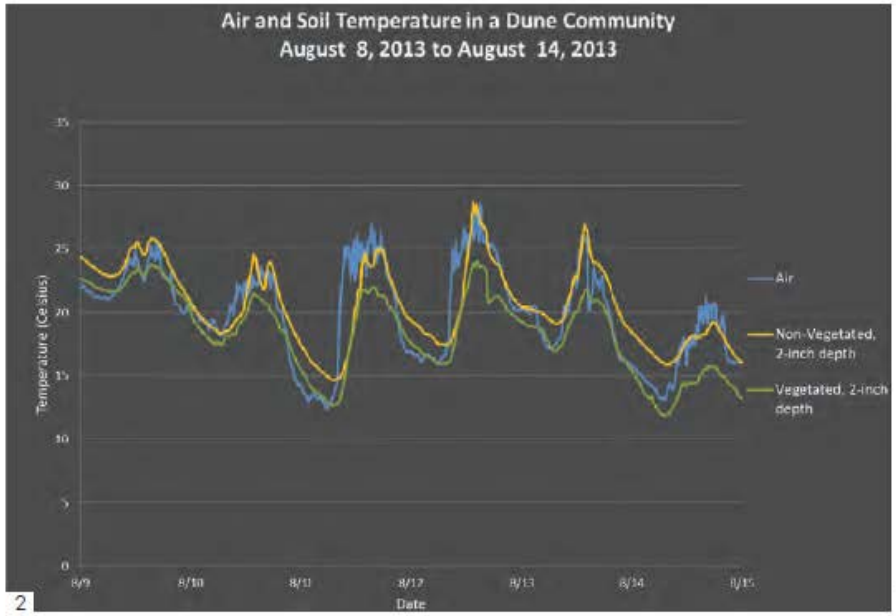
Design Concept:
The plants and characteristics of the Alvar and eastern Lake Ontario Dune plant communities were key drivers of the design. Planting highlights species' aesthetic characteristics, facilitates engagement, and incorporates important details such as mounding topography (dune) and visible stone (alvar).

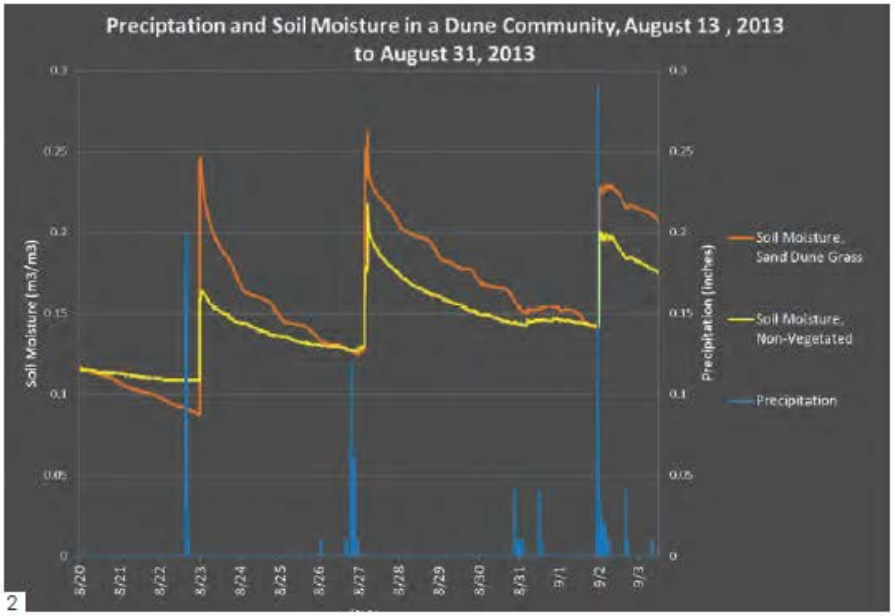
Plant Trials

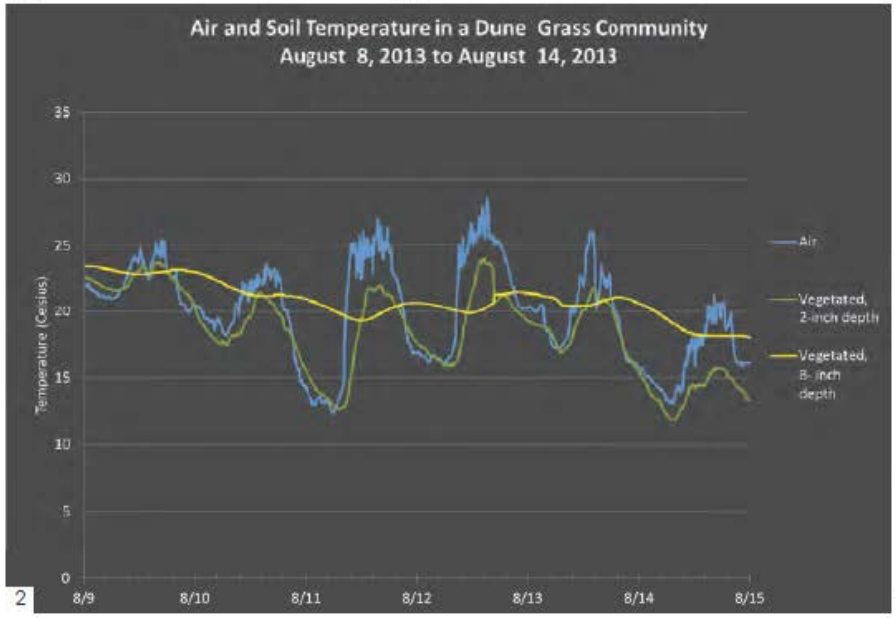
Testing Frames at SUNY ESF

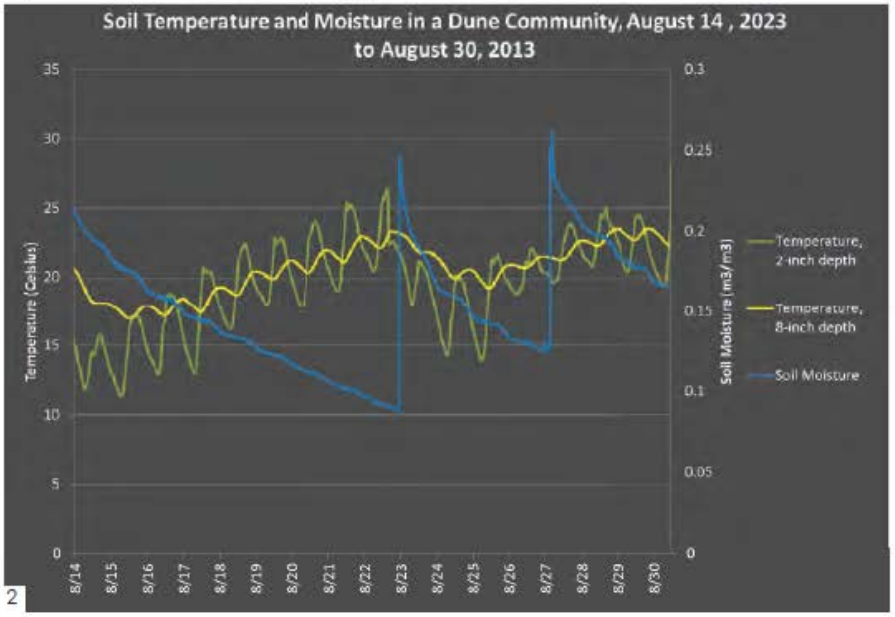
Project Due Diligence:

Soil Monitoring




Preciptation and Soil Moisture in a Dune Community, August 13 , 2013 to August 31, 2013
Soil Moisture (m3/m3)
Precipitation (inches)
Soil Moisture, Sand Dune Grass
Soil Moisture, Non-Vegetated
Precipitation


Air and Soil Temperature in a Dune Grass Community
August 8, 2013 to August 14, 2013
Temperature (Celsius)
Air
Vegetated, 2-inch depth
Vegetated, 8- inch depth


Soil Temperature and Moisture in a Dune Community, August 14 , 2023 to August 30, 2013
Temperature (Celsius)
Soil Moisture (m3/m3)
Temperature, 2-inch depth
Temperature, 8-inch depth
Soil Moisture

Air, Water and Temperature Analysis:
Comparisons from data on these variables reveal relationships consistent with other observations in the literature. Future studies will evaluate the impact these species may have on enhanced stormwater management.

First Season Images

2

1

1

2

First season images showing the established plantings in the fall. Blooms, leaf texture and color, and other characteristics are highlighted as the

Proposed ESF Academic Research Building

Phase I and II

Building Stormwater Management

Landscape Treatment

1 Limestone Boulder

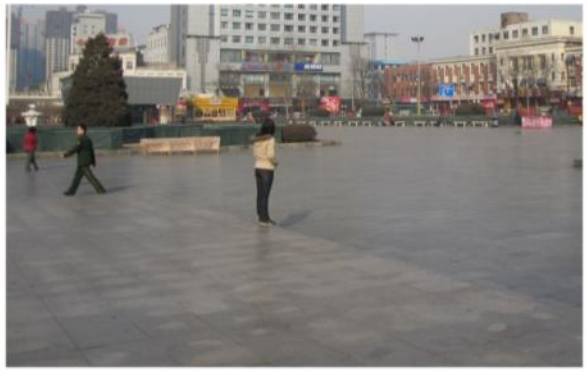
2 Boardwalk

3 Granular Trail

4 Stone Weir

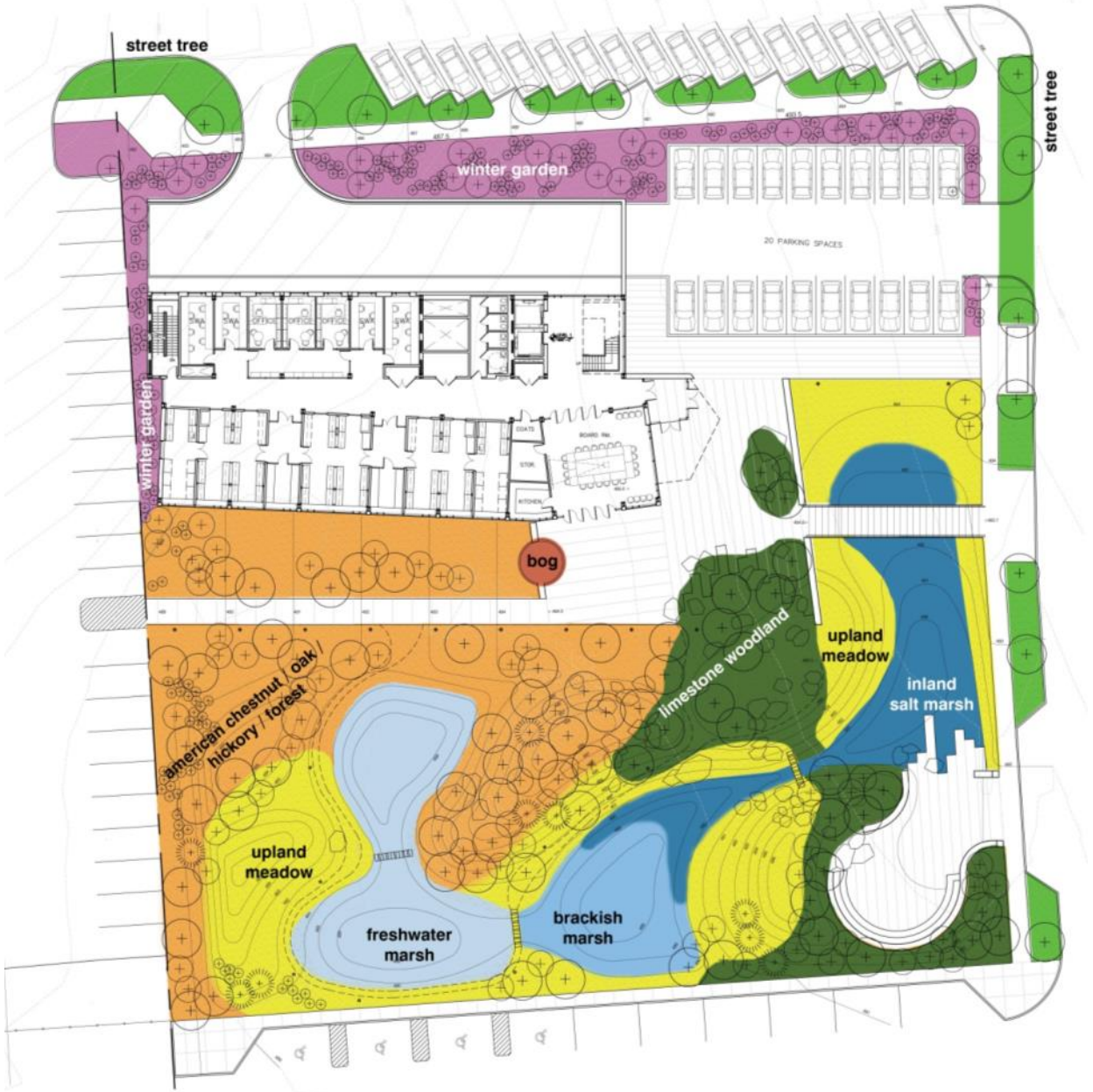
5 Salt Marsh Planted Quality

6 Site Lighting



7 Granite Plaza

standart street
henry street
stadium place
winter garden
service area
garage entry
bus shelter
plaza
boardwalk
raised bog
inland salt marsh
landscape sitting area
fresh water marsh
limestone woodland
sitting area
brackish marsh
snow storage
SHARED vehicular drop-off and snow storage access
fresh water marsh
ADA compliant trail
oakland street
centennial hall plaza


street tree
winter garden
20 PARKING SPACES
street tree
winter garden
bog
american chestnut / oak / hickory / forest
limestone woodland
upland meadow
inland salt marsh
upland meadow
freshwater marsh
brackish marsh

henry street
stadium place
property line
winter garden
garage access
20 PARKING SPACES
plaza extension
(13' wide)
30' wide snow storage access
(parking with flush curb condition)
bus shelter
parking drains
inland salt marsh
plaza
boardwalk
roof drains
raised bog
plaza drains
syracuse university parking
landscape sitting area
fresh water marsh
limestone woodland
sitting area
inland salt marsh
snow melt
SHARED vehicular drop-off and snow storage access
snow storage
sitting area
brackish marsh
fresh water marsh
ADA compliant trail
property line
existing vegetation and fence
oakland street
centennial hall plaza

Bibliography/References

- http://water.epa.gov/infrastructure/greeninfrastructure/index.cfm#tabs-1
- http://www.conservationfund.org/our-conservation-strategy/focus-areas/green-infrastructure/case-studies/
- http://www.dec.ny.gov/lands/58930.html
- http://news.wef.org/green-infrastructure-designs-win-u-s-epa-rainworks-challenge/
- http://ec.europa.eu/environment/nature/ecosystems/

- Creating multifunctional landscapes: how can the field of ecology inform the design of the landscape?
  ST Lovell, DM Johnston - Frontiers in Ecology and the Environment, 2008
- Designing landscapes for performance based on emerging principles in landscape ecology.
  ST Lovell, DM Johnston - Ecology & Society, 2009
- Downstream economic benefits from storm-water management
  JB Braden, DM Johnston
  Journal of Water Resources Planning and Management 130 (6), 498-505
- Downstream economic benefits of conservation development
  DM Johnston, JB Braden, TH Price
  Journal of water resources planning and management 132 (1), 35-43